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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G01B 17/00, 17/06

A1

(11) International Publication Number: **WO 99/06796**

(43) International Publication Date: 11 February 1999 (11.02.99)

(21) International Application Number: PCT/IE98/00070

(22) International Filing Date: 4 August 1998 (04.08.98)

(30) Priority Data:
S970574 1 August 1997 (01.08.97) IE

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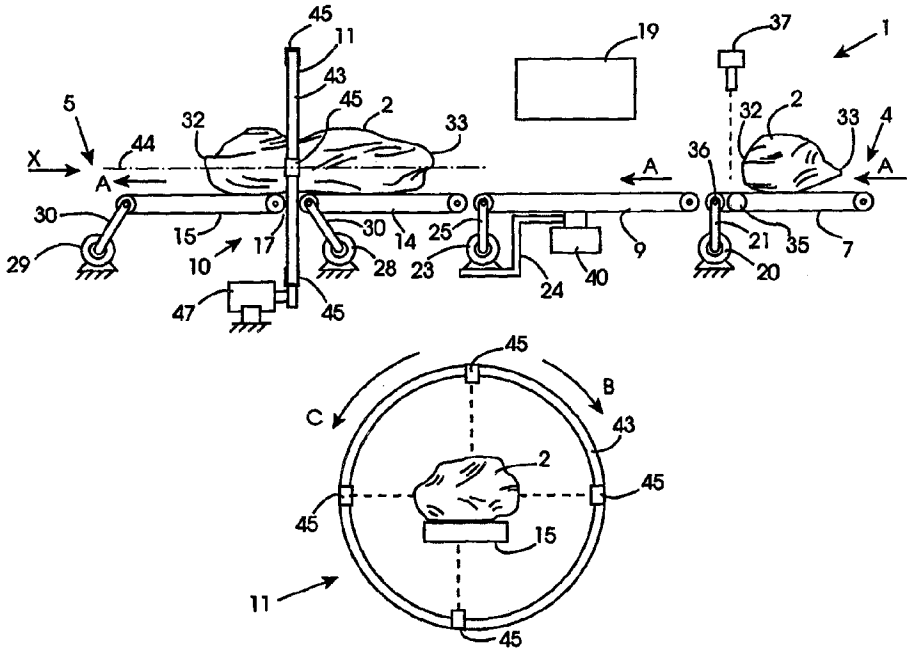
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: A METHOD AND APPARATUS FOR DETERMINING THE TOPOGRAPHICAL SURFACE SHAPE OF AN ARTICLE

(57) Abstract

Apparatus (1) for determining the topographical surface shape of a bulk meat product (2) comprises an infeed conveyor (7) in which the length of the bulk meat product (2) is determined. A weighing conveyor (9) weighs the bulk meat product (2), which is then transferred to a throughfeed conveyor (10) for passing the bulk meat product (2) through a scanning device (11) for scanning the circumferential surface of the bulk meat product (2) through 360° transversely of the direction of movement (arrow A) of the bulk meat product (2) through the scanning device (11). The scanning device (11) comprises a hoop–shaped carrier (43) on which four ultrasonic scanning heads (45) are mounted at 90° intervals to each other. A stepper motor (47) rotates the carrier (43) in incremental angular steps through 90° for performing 360° of scanning of the surface of the bulk meat product (2). The stepper motor (47) rotates the carrier (43) through 90° in the direction of the arrow B, and then in the reverse direction of the arrow C and so on so that the bulk meat product is scanned at intervals along its length as the carrier (43) is oscillated in the direction of the arrows B and C through 90°.



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"A method and apparatus for determining the topographical surface shape of an article"

The present invention relates to a method and apparatus for determining the topographical surface shape of an article, and in particular though not limited to a bulk meat product.

Meat production, in general, requires the butchering of meat into selected cuts for retail sales. The meat may be in the form of a large joint, a side, a half side, a quarter side or the like. Such large portions of meat will hereinafter referred to as bulk meat products. The meat cuts which are butchered from the bulk meat product for retail sales may be joint portions, steaks, sliced cuts, for example, rashers and the like. It is desirable that the yield from such bulk meat products should be maximised when preparing the cuts therefrom. Wastage should be minimised. In addition, customer requirements in terms of aesthetics of the cut must also be taken into account when preparing a bulk meat product for butchering, so that the shape, feel and quality of the resultant meat cuts is in accordance with customer requirements. Furthermore, in general, it is desirable that meat cuts when cut from a bulk meat product, should be of a predetermined weight.

It is common in the meat processing industry to subject bulk meat products to pressing and shaping prior to butchering, so that the cuts butchered from the bulk meat product will be of a desired shape, and in particular, the cuts can be more easily butchered from the bulk meat product to be a predetermined weight. Such pressure and shaping of bulk meat products can, if overpressing takes place, lead to damage to the meat, and in particular, to muscle tissue in the meat. This, in general, results in fragmentation of the meat when butchered into the meat cuts. It is therefore desirable to ensure overpressing of a bulk meat product does not occur. This, thus, requires a determination of the topographical surface shape of the bulk meat product prior to pressing. Additionally, in order that meat cuts can be butchered

from the bulk meat product of predetermined weight, the determination of the topographical surface shape of a bulk meat product is also required.

The present invention is directed towards providing a method and apparatus for determining the topographical surface shape of a bulk meat product, and indeed any article.

According to the invention, there is provided a method for determining the topographical surface shape of an article, wherein the method comprises the steps of

determining the length of the article in a first direction by a length determining means, and storing the length,

scanning the surface of the article through 360° transversely of the first direction at a plurality of intervals along the length of the article in the first direction for determining the cross-sectional shape of the article at the respective intervals,

storing the scanned data,

determining the topographical surface shape of the article from the stored length and the stored scanned data.

In one embodiment of the invention the weight of the article is determined.

In another embodiment of the invention the volume of the article is computed from the stored scanned data and the stored length.

In a further embodiment of the invention the average density of the article is computed from the volume and weight of the article so that the width of a slice of the article can be determined for producing a slice of the article of a predetermined weight.

In another embodiment of the invention the width of the slice the weight of which is to be of predetermined weight is determined in a direction parallel to the first direction.

Preferably, the scanning of the article is carried out by a scanning means mounted on a carrier means, the carrier means defining a rotational axis extending in the first direction.

Advantageously, the method comprises moving one of the carrier means and the article in a first angular direction about the rotational axis for causing the scanning means to scan 360° of the surface of the article, and moving the said one of the carrier means and the article in a second angular direction opposite to the first angular direction about the rotational axis, for causing the scanning means to scan 360° of the surface of the article at the next interval.

Preferably, the carrier means is angularly moved relative to the article.

In one embodiment of the invention at least two scanning means are provided on the carrier means equi-spaced apart circumferentially about the rotational axis, the method comprising the step of moving the carrier means in the first angular direction through an angle similar to the angular spacing between adjacent scanning means so that each scanning means scans the surface of the article through an angle similar to the angular spacing between adjacent scanning means.

In another embodiment of the invention four scanning means are provided at 90° intervals about the rotational axis of the carrier means.

In one embodiment of the invention the scanning means and the article is moved linearly in the first direction for scanning the article at the intervals along the length of the article.

In a further embodiment of the invention the article is moved in the first direction relative to the scanning means.

In a still further embodiment of the invention the article is moved continuously as the scanning means is scanning.

Ideally, the article is moved at a constant speed through the scanning means.

Additionally, the invention provides a method for determining the topographical surface shape of a bulk meat product, wherein the method comprises the steps of

determining the length of the bulk meat product in a first direction by a length determining means, and storing the length,

scanning the surface of the bulk meat product through 360° transversely of the first direction at a plurality of intervals along the length of the bulk meat product in the first direction for determining the cross-sectional shape of the bulk meat product at the respective intervals,

storing the scanned data,

determining the topographical surface shape of the bulk meat product from the stored length and the stored scanned data.

In one embodiment of the invention the weight of the bulk meat product is determined.

In another embodiment of the invention the volume of the bulk meat product is computed from the stored scanned data and the stored length.

In a further embodiment of the invention the average density of the bulk meat product is computed from the volume and weight of the bulk meat product so that the width of a slice of the bulk meat product can be determined for producing a slice of the bulk meat product of a predetermined weight.

In another embodiment of the invention the width of the slice the weight of which is to be of predetermined weight is determined in a direction parallel to the first direction.

Preferably, the scanning of the bulk meat product is carried out by a scanning means mounted on a carrier means, the carrier means defining a rotational axis extending in the first direction.

Advantageously, the method comprises moving one of the carrier means and the bulk meat product in a first angular direction about the rotational axis for causing the scanning means to scan 360° of the surface of the bulk meat product, and moving the said one of the carrier means and the bulk meat product in a second angular direction opposite to the first angular direction about the rotational axis, for causing the scanning means to scan 360° of the surface of the bulk meat product at the next interval.

Preferably, the carrier means is angularly moved relative to the bulk meat product.

In one embodiment of the invention at least two scanning means are provided on the carrier means equi-spaced apart circumferentially about the rotational axis, the method comprising the step of moving the carrier means in the first angular direction through an angle similar to the angular spacing between adjacent scanning means so that each scanning means scans the surface of the bulk meat product through an angle similar to the angular spacing between adjacent scanning means.

In another embodiment of the invention four scanning means are provided at 90° intervals about the rotational axis of the carrier means.

In one embodiment of the invention the scanning means and the bulk meat product is moved linearly in the first direction for scanning the bulk meat product at the intervals along the length of the bulk meat product.

In a further embodiment of the invention the bulk meat product is moved in the first direction relative to the scanning means.

In a still further embodiment of the invention the bulk meat product is moved continuously as the scanning means is scanning.

Ideally, the bulk meat product is moved at a constant speed through the scanning means.

Additionally, the invention provides apparatus for determining the topographical surface shape of an article, wherein the apparatus comprises

a length determining means for determining the length of the article in a first direction,

a scanning means for scanning the surface of the article through 360° transversely of the first direction at a plurality of intervals along the length of the article in the first direction for determining the cross-sectional shape of the article at the respective intervals,

a storing means for storing scanned data from the scanning means and the length of the article from the length determining means, and

a computing means for computing the topographical surface shape from the stored length and the stored scanned data.

In one embodiment of the invention a weighing means is provided for weighing the article, and the weight determined by the weighing means is stored in the storing means.

In another embodiment of the invention the computing means computes the volume of the article from the stored length and the stored scanned data.

In a further embodiment of the invention the computing means computes the average density of the article from the computed volume and the stored weight of the article.

Ideally, the scanning means is mounted on a carrier means, the carrier means defining a rotational axis extending in a first

direction, the carrier means being movable in a first angular direction about the rotational axis for causing the scanning means to scan 360° of the surface of the article through 360° and the carrier means being movable in a second angular direction opposite the first angular direction for causing the scanning means to scan 360° of the surface of the article at the next interval along the length of the article in the first direction.

In one embodiment of the invention the carrier means accommodates the article axially therethrough so that as the carrier means is being moved in the first and second angular directions the scanning means traces a locus which encircles the article.

In another embodiment of the invention the scanning means comprises at least one scanning head mounted on the carrier means.

Preferably, the scanning means comprises at least two scanning heads mounted on the carrier means and equi-spaced circumferentially around the rotational axis defined by the carrier means, the carrier means being movable in the first and second angular directions through respective angles similar to the angular spacing between adjacent scanning heads.

In one embodiment of the invention the scanning means comprises four scanning heads located at 90° intervals around the rotational axis of the carrier means, and the carrier means is movable through an angle of 90° in the first and second angular directions.

Ideally, a means for rotating the carrier means in the respective first and second angular directions is provided.

Preferably, the means for rotating the carrier means comprises a constant speed motor or a stepper motor.

In a further embodiment of the invention a carrier monitoring

means is provided for monitoring the movement of the carrier means as the carrier means is being moved in the first and second angular directions during scanning by the scanning means so that "X" and "Y" co-ordinates of respective points on the surface of the article scanned by the scanning means can be determined.

In one embodiment of the invention a throughfeed conveying means is provided for conveying the article through the scanning means.

In another embodiment of the invention the throughfeed conveying means is a constant speed conveying means.

Preferably, the throughfeed conveying means comprises an upstream conveying means and a downstream conveying means, the respective upstream and downstream conveying means being spaced apart to define a scanning gap for accommodating scanning of the article as the article is being passed from the upstream conveying means to the downstream conveying means across the scanning gap.

In one embodiment of the invention an infeed conveying means is provided for conveying the article to the throughfeed conveying means.

In another embodiment of the invention the length detecting means comprises a sensing means for detecting the respective opposite ends in the first direction of the article, and a conveyor monitoring means for monitoring the distance travelled by the infeed conveying means, between the times the scanning means detects the respective opposite ends of the article for determining the length of the article.

In one embodiment of the invention a counting means is provided for counting pulses from the monitoring means for determining the distance travelled by the infeed conveying means, the counting means being responsive to the sensing means detecting the leading end of the article for commencing counting of the pulses, and to

the sensing means detecting the trailing end of the article for ceasing the count, the counting means communicating with the computing means for computing the length of the article.

In a further embodiment of the invention the sensing means comprises a photosensor sensing means.

In one embodiment of the invention, the apparatus is suitable for determining the topographical surface shape of a bulk meat product.

The invention will be more clearly understood from the following description of a preferred embodiment thereof which is given by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is a schematic side elevational view of apparatus according to the invention for determining the topographical surface shape of a bulk meat product.

Fig. 2 is a schematic end elevational view of a portion of the apparatus of Fig. 1 in the direction of the arrow X of Fig. 1, and

Fig. 3 is a block representation of a control circuit for controlling the apparatus of Fig. 1.

Referring to the drawings, there is illustrated apparatus according to the invention indicated generally by the reference numeral 1 for determining the topographical surface shape of an article, in this case a bulk meat product. Two bulk meat products indicated by the reference numeral 2 are illustrated on the apparatus 1. The apparatus 1 comprises a main framework, which for ease of illustration and understanding of the invention is not shown, but which extends from an upstream end 4 of the apparatus 1 to a downstream end 5 of the apparatus 1. Typically, bulk meat

products are fed to the upstream end 4 of the apparatus 1 on a supply conveyor (not shown), and preferably, the bulk meat products 2 should be supplied spaced apart on the supply conveyor (not shown). A main conveying means for conveying the bulk meat products 2 through the apparatus 1 in a first linear direction, namely, in the direction of the arrow A comprises three belt conveyors, namely, an infeed conveyor 7, a weighing conveyor 9 and a throughfeed conveyor 10. The infeed conveyor 7 is located at the upstream end 4 of the apparatus 1 for receiving the bulk meat products 2 from the supply conveyor (not shown). The weighing conveyor 9 is provided for weighing the individual bulk meat products 2, and is located downstream of the infeed conveyor 7, and is aligned therewith and adjacent thereto for receiving the bulk meat products 2 for weighing. The throughfeed conveyor 10 which is aligned with and adjacent to the weighing conveyor 9 receives the bulk meat products 2 from the weighing conveyor 9 for conveying the bulk meat products 2 through a scanning means, namely, a scanning device 11 through which the bulk meat products 2 are conveyed as will be described in more detail below. The throughfeed conveyor 10 is formed by a pair of conveyors, namely, an upstream conveyor 14 which receives the bulk meat products 2 from the weighing conveyor 9, and a downstream conveyor 15. The upstream and downstream conveyors 14 and 15, respectively, are aligned with each other but spaced apart to form a scanning gap 17 for facilitating 360° scanning of the bulk meat products 2 by the scanning device 11 as the respective bulk meat products 2 are passed across the scanning gap 17. The scanned bulk meat products 2 are discharged from the downstream conveyor 15, typically onto a take-away conveyor (not shown). The conveyors 7, 9, 10, 14 and 15 are all mounted on the main framework (not shown).

The apparatus 1 is operated under the control of a control circuit 18 which is described in more detail below and is housed in a control box 19. An infeed conveyor drive means comprising an electrically powered infeed drive motor 20 is mounted on the main framework (not shown) and drives the infeed conveyor 7 under the

control of the control circuit 18 through a chain/sprocket drive transmission 21. A weighing conveyor drive means comprising an electrically powered drive motor 23 drives the weighing conveyor 9 under the control of the control circuit 18. The drive motor 23 is mounted in a subframework 24 of the weighing conveyor 9, and drives the weighing conveyor 9 through a chain/sprocket drive transmission 25. The upstream and downstream conveyors 14 and 15 are each driven by corresponding throughfeed drive means, namely, electrically powered drive motors 28 and 29, which are mounted on the main framework (not shown). The drive motors 28 and 29 are constant speed drive motors for driving the respective upstream and downstream conveyors 14 and 15, respectively, at the same constant speed under the control of the control circuit 18. Chain/sprocket drive transmissions 30 transfer drive from the drive motors 28 and 29 to the respective upstream and downstream conveyors 14 and 15.

A length determining means is provided in conjunction with the infeed conveyor 7 for determining the length of each bulk meat product 2 in the first direction, namely, in the direction of the arrow A from a leading end 32 to a trailing end 33 of the bulk meat products 2. The length determining means comprises a conveyor monitoring means, namely, an encoder 35 which is coupled to a drive shaft 36 of the infeed conveyor 7, which is driven by the drive transmission 21, for determining the angular rotation of the drive shaft 36, for in turn determining the distance travelled by the infeed conveyor 7. A photosensor 37 located above the infeed conveyor 7 detects the respective leading and trailing ends 32 and 33, respectively, of each bulk meat product 2. A counter 38, see Fig. 3, is provided for counting pulses from the encoder 35 which correspond to the angular rotation of the drive shaft 36. The control circuit 18 reads the number of pulses counted by the counter 38 from the time the photosensor 17 detects the leading end 32 until the photosensor 37 detects the trailing end 33 of each bulk meat product 2. In this way, the control circuit 18 as will be described below determines the length of the bulk meat

product 2.

A weighing means, namely, a load cell 40 mounted on the main framework (not shown) supports the weighing conveyor 9 and the subframework 24 for weighing each bulk meat product 2 on the weighing conveyor 9. The drive motor 23 under the control of the control circuit 18 is momentarily stopped for stopping the weighing conveyor 9 when each bulk meat product 2 is supported on the weighing conveyor 9 for facilitating accurate weighing of the bulk meat products 2.

The scanning device 11 is arranged for scanning the surface of each bulk meat product 2 through 360° transversely of the direction of movement of the bulk meat products 2 in the direction of the arrow A at predetermined intervals as the bulk meat product 2 is passed through the scanning device 11. Signals from the scanning device 11 are fed to the control circuit which computes and stores particulars of the transverse cross-sectional area and the transverse cross-sectional shape of the bulk meat products 2 at the predetermined intervals. This data on the transverse cross-sectional area and the transverse cross-sectional shape of each bulk meat product 2 combined with the length of the bulk meat product 2 between its leading and trailing ends 32 and 33, respectively, permits the topographical surface shape of the bulk meat product 2 to be determined.

The scanning device 11 comprises a carrier means, namely, a hoop shaped carrier 43 which extends around the throughfeed conveyor 10 and defines a rotational axis 44 which extends in the direction of the arrow A. The carrier 43 is mounted in the main framework (not shown) for rotation about the rotational axis 44. Four ultrasonic scanning heads 45 for scanning the surface of each bulk meat product 2 are mounted on the carrier 43, and are located at equi-spaced intervals circumferentially around the carrier 43, namely, at 90° intervals to each other. The scanning heads 45 are arranged to direct their scanning beams inwardly at the bulk meat

product 2 on the throughfeed conveyor 10 offset from each other for avoiding interscanning head interference, this can most clearly be seen in Fig. 2.

A drive means, namely, a stepper motor 47 mounted on the main framework (not shown) rotates the carrier 43 in a first angular direction, namely, in the direction of the arrow B through 90°, so that each scanning head 45 scans 90° of the surface of the bulk meat product 2 as it is passing through the carrier 43, thereby providing a scan of 360° of the surface of the bulk meat product 2. The stepper motor 47 also rotates the carrier 43 in a second angular direction, namely, in the direction of the arrow C, opposite to the first angular direction through 90° for carrying out a second scan by each scanning head 45 through 90°, thereby providing a second 360° scan of the surface of the bulk meat product 2. Accordingly, the stepper motor 47 under the control of the control circuit 18 continuously oscillates the carrier 43 about the rotational axis 44 as each bulk meat product 2 is being passed through the carrier 43. Thus, the surface of the bulk meat product 2 is scanned through 360° at intervals as the bulk meat product 2 is passed through the carrier 43, each interval corresponding to one 90° rotation of the carrier 43. In this way, the control circuit 18 can determined by "X" and "Y" co-ordinates from the scanned data, coupled with the control signal issued to the stepper motor 47 "X" and "Y" co-ordinates in the plane of the carrier 43 of a plurality of points around the circumferential surface of the bulk meat product 2 scanned by the scanning device 11. The "Z" co-ordinate of each point in the direction of the arrow A is determined from the stored length of the bulk meat product 2 and the speed at which the upstream and downstream conveyors 14 and 15 are driven by their respective drive motors 28 and 29.

Turning now to the control circuit 18, the control circuit 18 comprises a microprocessor 50 which controls the circuit 18, and the apparatus 1. The drive motor 20 of the infeed conveyor 7 is

operated under the control of the microprocessor 50 through a driver 51. The photosensor 37 comprises a light source, namely, a laser light source 52 which is operated under the control of the microprocessor 50 through a driver 53. A sensor 54 in the photosensor 37 is sensitive to laser light from the light source 52 reflected by the bulk meat product 2. Signals from the sensor 54 are fed through an analogue to digital converter 55 and are read by the microprocessor 50. The encoder 35 which monitors the angular rotation of the drive shaft 36 of the infeed conveyor 7 outputs a pulse at predetermined angular intervals of rotation of the drive shaft 36, which may be as low as 5° intervals of rotation. The pulses are fed through an analogue to digital converter 56 to the counter 38. The counter 38 is operated under the control of the microprocessor 18 for counting the number of pulses outputted by the sensor 54 from the time the photosensor 37 detects the leading end 32 until the trailing end 35 of the bulk meat product 2 has been detected, for in turn determining the length of the bulk meat product 2 which is computed by a computing means provided by software in the control circuit microprocessor 50. The computed length of the bulk meat product 2 is stored in a random access memory (RAM) 57.

The drive motor 23 of the weighing conveyor 9 is operated under the control of the microprocessor 50 through a driver 58, and as discussed above, when each bulk meat product 2 is fully supported by the weighing conveyor 9, the drive motor 23 is momentarily stopped for facilitating weighing of the bulk meat product 2 by the load cell 40. Signals from the load cell 40 are fed back to the microprocessor 50 through an analogue to digital converter 59, and the computing means provided by software in the microprocessor 50 computes the weight of the bulk meat product 2 from signals received from the load cell 40. The computed weight is stored in the RAM 57.

The motors 28 and 29 of the upstream and downstream conveyors 14 and 15 are operated under the control of the microprocessor 50 by

drivers 60 and 61, respectively. The stepper motor 47 is operated under the control of the microprocessor 50 through a driver 63. The signals from the scanning heads 45 are fed to the microprocessor 50 through analogue to digital converters 65 to 68. The microprocessor 50 operates the stepper motor 47 to rotate the carrier 43 in incremental angular steps, typically of 5° intervals. Each time the carrier 43 is stopped, signals from the scanning heads 45 are read by the microprocessor 50. The computing means provided by suitable software in the microprocessor 50 computes the "X" and "Y" co-ordinates in the plane of the carrier 43 of the four points around the surface of the bulk meat product 2 from the signals from the scanning heads 45 knowing the angular positions of the scanning heads 45 around the rotational axis 44 of the carrier 43. The angular positions of the scanning heads 45 is determined by the software from the number of angular increments by which the carrier 43 has been rotated in each 90° cycle. Such software will be well known to those skilled in the art. The "Z" co-ordinate of each point is determined from the stored length "L" of the bulk meat product 2 and from the speed at which the upstream and downstream conveyors 14 and 15 are being driven. At the end of scanning of the bulk meat product 2, the computing means provided by the suitable software in the microprocessor 50 then computes the transverse cross-sectional area and the transverse cross-sectional shape of the bulk meat product 2 at the respective intervals. From this, and the "Z" co-ordinates of the respective points on the surface of the bulk meat product 2, the entire shape of the bulk meat product 2 can be determined, as can its volume. A three dimensional image of the bulk meat product 2 can then be prepared by suitable software in the microprocessor 50. The density of the bulk meat product 2 is computed by dividing the weight of the bulk meat product 2 by the volume of the bulk meat product 2.

The volume, weight, density and three dimensional image of the bulk meat product 2 is then stored in the RAM 57, and may be fed out from the microprocessor 50 on a parallel port 69 for use by

other meat processing apparatus. For example, the stored data on each bulk meat product 2 can be fed to apparatus for preparing cuts of meat so that the bulk meat product 2 can be sliced to provide slices of predetermined weight. From the stored data, the butchering apparatus would be able to determine the width of each slice to provide a slice of a predetermined weight. Additionally, the stored data may be fed to a pressing and shaping apparatus if the bulk meat product is to be subsequently pressed and shaped. The stored data would allow the pressing and shaping of the bulk meat product to be controlled to avoid overpressing.

In use, bulk meat products 2 are sequentially fed from a supply conveyor (not shown) or other suitable supply means to the infeed conveyor 7. As each bulk meat product 2 passes along the infeed conveyor 7, the length of the bulk meat product 2 from its leading end 32 to its trailing end 33 is determined from signals received by the control circuit 18 from the photosensor 37 and the encoder 35. The length of the respective bulk meat products 2 is stored in the RAM 57. The bulk meat products 2 are sequentially transferred from the infeed conveyor 7 to the weighing conveyor 9 where the weight of each bulk meat product 2 is determined by the load cell 40 under the control of the control circuit 18. The weight of the respective bulk meat products 2 is stored in the RAM 57.

The bulk meat products 2 are then transferred from the weighing conveyor 9 to the upstream conveyor 14 of the throughfeed conveyor 10 and in turn passed through the scanning device 11 onto the downstream conveyor 14. Operation of the scanning device 11 is commenced as the scanning heads 45 detect the leading end 32 of the bulk meat product 2, and operation of the scanning device 11 is terminated by detection of the trailing end 33 of the bulk meat product 2 by the scanning heads 45. The scanning device determines the transverse cross-sectional area and transverse cross-sectional shape of the bulk meat products 2 at predetermined intervals as the bulk meat products 2 are being passed through the

carrier 43, and signals from the scanning heads and the angular position of the carrier 43 determined from the stepper motor 47 are stored in the RAM 57, where they are subsequently used for computing the transverse cross-sectional area and transverse cross-sectional shape of the bulk meat product 2. The density, volume and overall shape of the bulk meat product 2 are then computed and stored in the RAM 57 for outputting through a parallel port 69 of the microprocessor 50 to other meat processing apparatus to which the bulk meat product 2 is to be transferred.

While the scanning heads have been described as being ultrasonic scanning heads, the scanning heads could be laser scanners, or any other suitable scanners.

While the apparatus and method have been described for determining the topographical surface shape, volume average density and transverse cross-sectional area of a bulk meat product, the method and apparatus may be used for determining these parameters of any article.

The advantages of the invention are many. A particularly important advantage of the invention is that it provides relatively simple and straightforward apparatus and method for determining the volume, average density and topographical shape of a bulk meat product or any other article.

CLAIMS

1. A method for determining the topographical surface shape of an article (2), characterised in that the method comprises the steps of

determining the length of the article (2) in a first direction (A) by a length determining means (35,37), and storing the length,

scanning the surface of the article (2) through 360° transversely of the first direction (A) at a plurality of intervals along the length of the article (2) in the first direction for determining the cross-sectional shape of the article (2) at the respective intervals,

storing the scanned data,

determining the topographical surface shape of the article (2) from the stored length and the stored scanned data.

2. A method as claimed in Claim 1 characterised in that the weight of the article (2) is determined.

3. A method as claimed in Claim 1 or 2 characterised in that the volume of the article (2) is computed from the stored scanned data and the stored length.

4. A method as claimed in Claim 3 characterised in that the average density of the article (2) is computed from the volume and weight of the article so that the width of a slice of the article can be determined for producing a slice of the article of a predetermined weight.

5. A method as claimed in Claim 4 characterised in that the width of the slice the weight of which is to be of predetermined weight is determined in a direction parallel to the first direction (A).

6. A method as claimed in any preceding claim characterised in that the scanning of the article is carried out by a scanning

means (45) mounted on a carrier means (43), the carrier means (43) defining a rotational axis (44) extending in the first direction.

7. A method as claimed in Claim 6 characterised in that the method comprises moving one of the carrier means (43) and the article (2) in a first angular direction (B) about the rotational axis (44) for causing the scanning means (45) to scan 360° of the surface of the article, and moving the said one of the carrier means (43) and the article (2) in a second angular direction (C) opposite to the first angular direction (B) about the rotational axis (44), for causing the scanning means (45) to scan 360° of the surface of the article at the next interval.

8. A method as claimed in Claim 6 or 7 characterised in that the carrier means (43) is angularly moved relative to the article.

9. A method as claimed in any of Claims 6 to 8 characterised in that at least two scanning means (45) are provided on the carrier means (31) equi-spaced apart circumferentially about the rotational axis (44), the method comprising the step of moving the carrier means (43) in the first angular direction (B) through an angle similar to the angular spacing between adjacent scanning means (45) so that each scanning means (45) scans the surface of the article (2) through an angle similar to the angular spacing between adjacent scanning means (45).

10. A method as claimed in Claim 9 characterised in that four scanning means (45) are provided at 90° intervals about the rotational axis (44) of the carrier means (31).

11. A method as claimed in any preceding claim characterised in that one of the scanning means and the article is moved linearly in the first direction for scanning the article at the intervals along the length of the article.

12. A method as claimed in Claim 11 characterised in that the

article (2) is moved in the first direction (A) relative to the scanning means (45).

13. A method as claimed in Claim 12 characterised in that the article (2) is moved continuously as the scanning means (45) is scanning.

14. A method as claimed in Claim 13 characterised in that the article (2) is moved at a constant speed through the scanning means (45).

15. A method for determining the topographical surface shape of a bulk meat product (2), characterised in that the method comprises the steps of

determining the length of the bulk meat product (2) in a first direction (A) by a length determining means (35,37), and storing the length,

scanning the surface of the bulk meat product (2) through 360° transversely of the first direction (A) at a plurality of intervals along the length of the bulk meat product (2) in the first direction for determining the cross-sectional shape of the bulk meat product (2) at the respective intervals,

storing the scanned data,

determining the topographical surface shape of the bulk meat product (2) from the stored length and the stored scanned data.

16. A method as claimed in Claim 15 characterised in that the weight of the bulk meat product (2) is determined.

17. A method as claimed in Claim 15 or 16 characterised in that the volume of the bulk meat product (2) is computed from the stored scanned data and the stored length.

18. A method as claimed in Claim 17 characterised in that the average density of the bulk meat product (2) is computed from the volume and weight of the bulk meat product so that the width of a

slice of the bulk meat product can be determined for producing a slice of the bulk meat product of a predetermined weight.

19. A method as claimed in Claim 18 characterised in that the width of the slice the weight of which is to be of predetermined weight is determined in a direction parallel to the first direction (A).

20. A method as claimed in any of Claims 15 to 19 characterised in that the scanning of the bulk meat product is carried out by a scanning means (45) mounted on a carrier means(43), the carrier means (43) defining a rotational axis (44) extending in the first direction.

21. A method as claimed in Claim 20 characterised in that the method comprises moving one of the carrier means (43) and the bulk meat product (2) in a first angular direction (B) about the rotational axis (44) for causing the scanning means (45) to scan 360° of the surface of the bulk meat product, and moving the said one of the carrier means (43) and the bulk meat product (2) in a second angular direction (C) opposite to the first angular direction (B) about the rotational axis (44), for causing the scanning means (45) to scan 360° of the surface of the bulk meat product at the next interval.

22. A method as claimed in Claim 20 or 21 characterised in that the carrier means (43) is angularly moved relative to the bulk meat product.

23. A method as claimed in any of Claims 20 to 22 characterised in that at least two scanning means (45) are provided on the carrier means (31) equi-spaced apart circumferentially about the rotational axis (44), the method comprising the step of moving the carrier means (43) in the first angular direction (B) through an angle similar to the angular spacing between adjacent scanning means (45) so that each scanning means (45) scans the surface of

the bulk meat product (2) through an angle similar to the angular spacing between adjacent scanning means (45).

24. A method as claimed in Claim 23 characterised in that four scanning means (45) are provided at 90° intervals about the rotational axis (44) of the carrier means (31).

25. A method as claimed in any of Claims 15 to 24 characterised in that one of the scanning means and the bulk meat product is moved linearly in the first direction for scanning the bulk meat product at the intervals along the length of the bulk meat product.

26. A method as claimed in Claim 25 characterised in that the bulk meat product (2) is moved in the first direction (A) relative to the scanning means (45).

27. A method as claimed in Claim 26 characterised in that the bulk meat product (2) is moved continuously as the scanning means (45) is scanning.

28. A method as claimed in Claim 27 characterised in that the bulk meat product (2) is moved at a constant speed through the scanning means (45).

29. Apparatus for determining the topographical surface shape of an article (2), characterised in that the apparatus comprises

a length determining means (35,37) for determining the length of the article in a first direction (A),

a scanning means (45) for scanning the surface of the article through 360° transversely of the first direction at a plurality of intervals along the length of the article in the first direction for determining the cross-sectional shape of the article at the respective intervals,

a storing means (57) for storing scanned data from the scanning means and the length of the article (2) from the length

determining means, and

a computing means (50) for computing the topographical surface shape from the stored length and the stored scanned data.

30. Apparatus as claimed in Claim 29 characterised in that a weighing means (40) is provided for weighing the article, and the weight determined by the weighing means (40) is stored in the storing means (57).

31. Apparatus as claimed in Claim 29 or 30 characterised in that the computing means (50) computes the volume of the article (4) from the stored length and the stored scanned data.

32. Apparatus as claimed in Claim 31 characterised in that the computing means (50) computes the average density of the article from the computed volume and the stored weight of the article.

33. Apparatus as claimed in any of Claims 29 to 32 characterised in that the scanning means (45) is mounted on a carrier means (43), the carrier means (31) defining a rotational axis (44) extending in a first direction (A), the carrier means (43) being movable in a first angular direction (B) about the rotational axis (44) for causing the scanning means (45) to scan 360° of the surface of the article through 360° and the carrier means (43) being movable in a second angular direction (C) opposite the first angular direction for causing the scanning means (45) to scan 360° of the surface of the article at the next interval along the length of the article in the first direction.

34. Apparatus as claimed in Claim 33 characterised in that the carrier means (43) accommodates the article axially therethrough so that as the carrier means (43) is being moved in the first and second angular directions the scanning means (45) traces a locus which encircles the article.

35. Apparatus as claimed in Claim 33 or 34 characterised in that

the scanning means (45) comprises at least one scanning head (45) mounted on the carrier means (43).

36. Apparatus as claimed in any of Claims 33 to 35 characterised in that the scanning means (45) comprises at least two scanning heads (45) mounted on the carrier means (43) and equi-spaced circumferentially around the rotational axis (44) defined by the carrier means (43), the carrier means (43) being movable in the first and second angular directions through respective angles similar to the angular spacing between adjacent scanning heads.

37. Apparatus as claimed in Claim 36 characterised in that the scanning means (45) comprises four scanning heads (45) located at 90° intervals around the rotational axis (44) of the carrier means (43), and the carrier means (43) is movable through an angle of 90° in the first and second angular directions.

38. Apparatus as claimed in any of Claims 33 to 37 characterised in that a means (47) for rotating the carrier means (43) in the respective first and second angular directions is provided.

39. Apparatus as claimed in Claim 38 characterised in that the means (47) for rotating the carrier means comprises a constant speed motor (47) or a stepper motor.

40. Apparatus as claimed in any of Claims 33 to 39 characterised in that a carrier monitoring means (47) is provided for monitoring the movement of the carrier means as the carrier means (43) is being moved in the first and second angular directions during scanning by the scanning means (45) so that "X" and "Y" co-ordinates of respective points on the surface of the article scanned by the scanning means can be determined.

41. Apparatus as claimed in any of Claims 29 to 40 characterised in that a throughfeed conveying means (10) is provided for conveying the article through the scanning means.

42. Apparatus as claimed in Claim 41 characterised in that the throughfeed conveying means (10) is a constant speed conveying means.

43. Apparatus as claimed in Claim 41 or 42 characterised in that the throughfeed conveying means (10) comprises an upstream conveying means (14) and a downstream conveying means (15), the respective upstream and downstream conveying means (14,15) being spaced apart to define a scanning gap (17) for accommodating scanning of the article as the article is being passed from the upstream conveying means (14) to the downstream conveying means (15) across the scanning gap (17).

44. Apparatus as claimed in any of Claims 41 to 43 characterised in that an infeed conveying means (7) is provided for conveying the article to the throughfeed conveying means (10).

45. Apparatus as claimed in Claim 44 characterised in that the length detecting means (35,37) comprises a sensing means (37) for detecting the respective opposite ends (32,33) in the first direction of the article (2), and a conveyor monitoring (35) means for monitoring the distance travelled by the infeed conveying means (7), between the times the scanning means (37) detects the respective opposite ends (32,33) of the article (2) for determining the length of the article.

46. Apparatus as claimed in Claim 45 characterised in that a counting means (38) is provided for counting pulses from the monitoring means (35) for determining the distance travelled by the infeed conveying means (7), the counting means (38) being responsive to the sensing means (37) detecting the leading end (32) of the article (2) for commencing counting of the pulses, and to the sensing means (37) detecting the trailing end (33) of the article for ceasing the count, the counting means (38) communicating with the computing means (50) for computing the

length of the article.

47. Apparatus as claimed in Claim 46 characterised in that the sensing means (37) comprises a photosensor sensing means (37).

48. Apparatus as claimed in any of Claims 29 to 47 characterised in that the apparatus is adapted for determining the topographical surface shape of a bulk meat product.

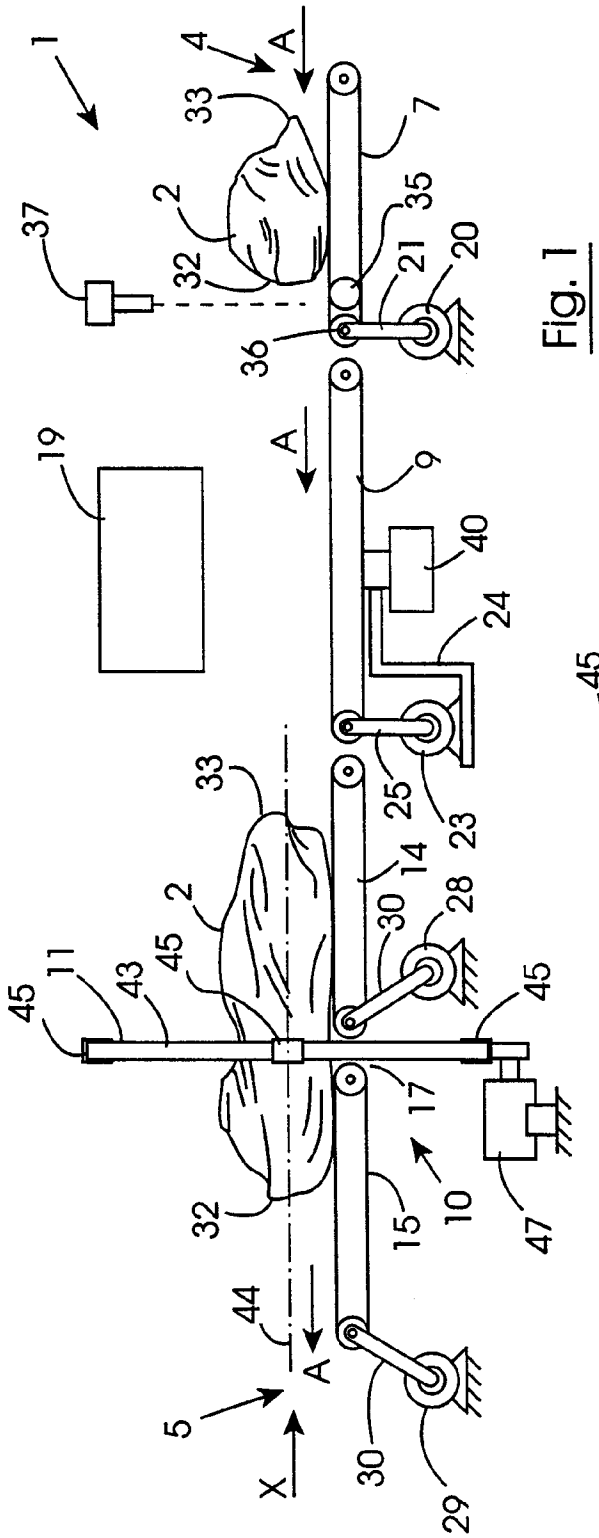

Fig. 1

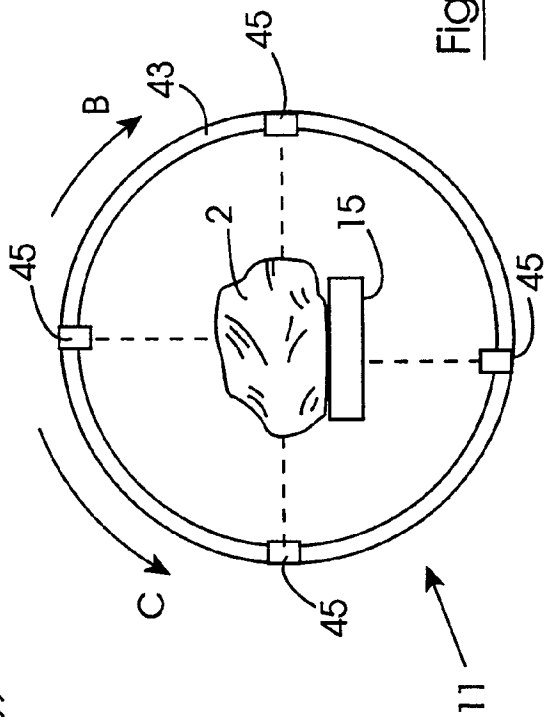

Fig. 2

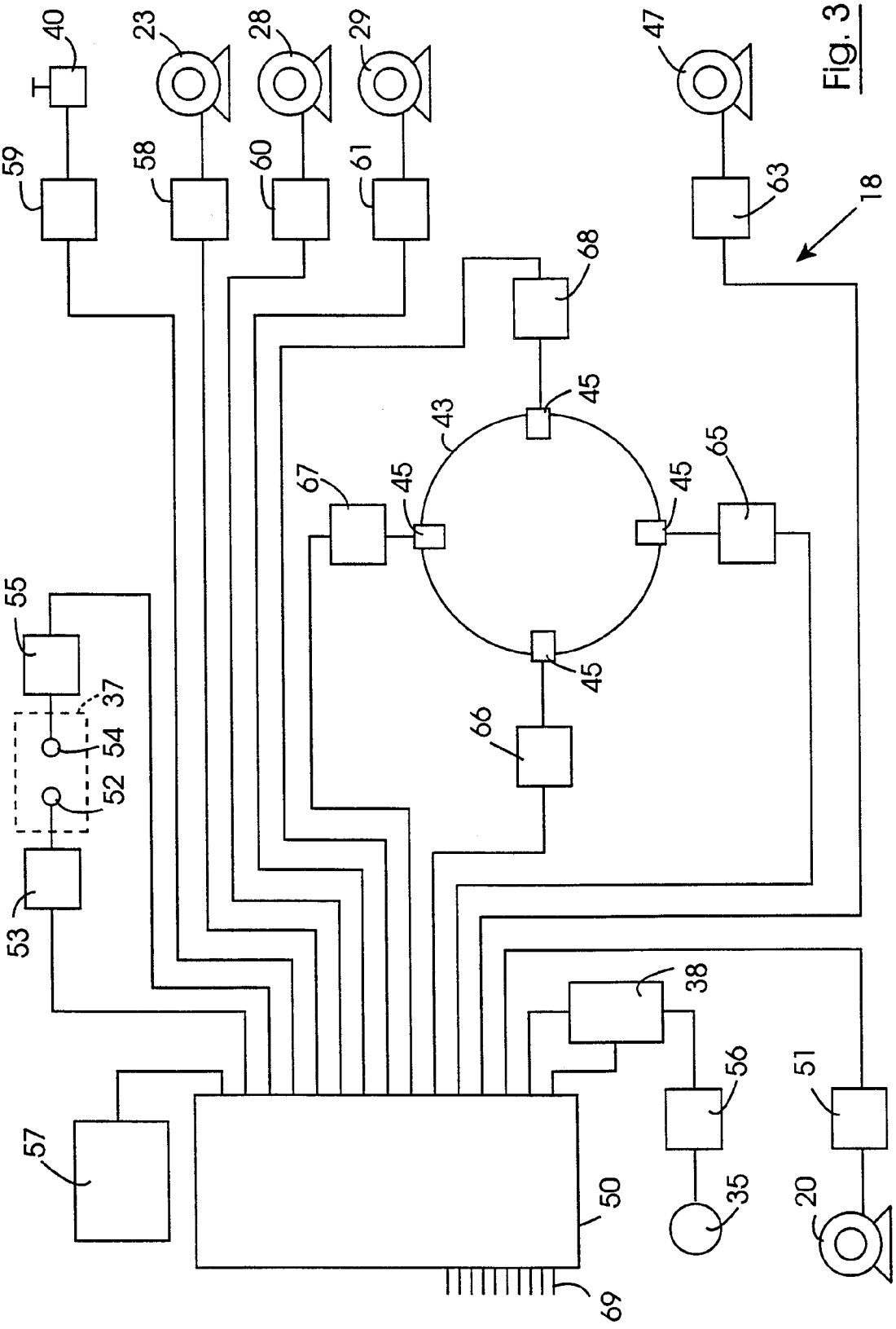

Fig. 3

INTERNATIONAL SEARCH REPORT

Interr. al Application No
PCT/IE 98/00070

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01B17/00 G01B17/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01B A22C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 44 18 036 A (SIEMENS AG) 30 November 1995 see column 3 - column 4; figures 1-5	1,15,29, 41
Y		3,6,8, 17,20, 22,31,48

Y	EP 0 429 711 A (FRISCO-FINDUS AG) 5 June 1991 see page 3 - page 4; figures 1,2	3,17,31, 48
A		2,5,16, 18,19, 30,32

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 October 1998	30/10/1998

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Inter. nal Application No
PCT/IE 98/00070

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	FR 2 606 140 A (VICAIRE M.) 6 May 1988 see page 3 - page 5; figures 1-4	6,8,20, 22
A		1,7,9, 10,15, 21,23, 29,33, 35,36
A	US 5 163 865 A (SMITH L.J.) 17 November 1992 see abstract; figures 1,2	1,15,29

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